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DEPARTMENT OF THE ARMY
UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36360

STEBG-TD (6) (11) 29 JUL 1966

SUBJECT: Letter Report, Product Improvement Test of Cobalt-Steel Leading-Edge Main-Rotor Blades in the UH-1D Helicopter, RDT&E Project No. ________________, USATECOM Project No. 4-5-0151-08

(9) Letter rept. (12) 20p.

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(16) USATECOM-4-5-0151-08

1. References.

a. TCREC Technical Report 62-111, "Helicopter Rotor Blade Erosion Protective Materials," US Army Transportation Research Command, December 1962.

b. Report of Test, Project No. AVN 1562, "Service Test of the YUH-1D Helicopter," US Army Aviation Board, 28 December 1962.

c. Letter, Bell Helicopter Company, 8 March 1965, subject: "Service Evaluation of Main Rotor Blades with Erosion Resistant Leading Edge Materiel."

d. Letter, SMOSM-EELUH-1-19, Headquarters, US Army Aviation Materiel Command, 28 April 1965, subject: "Main Rotor Blades with Cobalt Leading Edge."

e. Letter, SMOSM-PAIUI, Headquarters, US Army Aviation Materiel Command, 29 April 1965, subject: "Service Evaluation of Main Rotor Blades with Erosion Resistant Leading Edge Materiel."

f. Report of Test, USAAML Technical Report 65-39, "Polyurethane as Erosion Resistant Material for Helicopter Rotor Blades," US Army Aviation Materiel Laboratories, May 1965.

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g. Letter, AMCPM-IR-T, Headquarters, US Army Materiel Command, 4 May 1965, subject: "UH-1 Actions."

h. Report of Test, USATECOM Project No. 4-3-5220-02, DA Project No. 1R179191-D-684, "Military Potential Test of the Helicopter Rotor Blade Erosion-Preventive Kits," US Army Aviation Test Board, 10 June 1965.

i. Letter, STEBG-TP-A, US Army Aviation Test Board, 9 September 1965, subject: "Iroquois Test Coordination Meeting."

j. Message, STEBG-TD-E 9-29, President, US Army Aviation Test Board, 10 September 1965, subject: "Cobalt Leading Edge Main Rotor Blades."

k. Letter, STEBG-TP-A, US Army Aviation Test Board, 19 October 1965, subject: "Iroquois Test Coordination Meeting."

l. Letter, SMOSM-EAA, Headquarters, US Army Aviation Materiel Command, 28 October 1965, subject: "UH-1 Barrier Filter Particle Separator Meeting."

m. Plan of Test, USATECOM Project No. 4-5-0151-08, "Product Improvement Test of Cobalt Steel Leading Edge Main Rotor Blades in UH-1D Helicopter," US Army Aviation Test Board, 15 December 1965.

n. Final Report of Test, USATECOM Project No. 4-3-0150-16, "Product Improvement Test (Comparative Evaluation) of the T53-L-11 Engine Inlet-Air Barrier Filter and Particle Separator," US Army Aviation Test Board, 15 June 1966.

2. Authority.

a. Directive.

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(1) Letter, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 27 January 1965, subject: "Test Directive, USATECOM Project No. 4-5-0151-( ), Product Improvement Test, UH-1D Items."

(2) USATECOM Project Transcript Sheet, AMSTE-BG, 22 June 1965, USATECOM Project No. 4-5-0151-08, subject: "Cobalt Steel ~~Leading~~ Edge Blades."

The purpose of this research is

b. Purpose. To provide the Iroquois Project Manager with the results of operational experience on product-improved cobalt-steel leading-edge main-rotor blades on the UH-1D Helicopter relative to their suitability in resisting sand and dust erosion as compared with the standard rotor blades.

3. Description of Materiel.

a. The vehicles used for this test were UH-1D Utility Helicopters powered by a T53-L-11, 1100-shaft-horsepower gas-turbine engine. The helicopters incorporate 48-foot diameter, two-bladed main rotors and two-bladed antitorque rotors.

b. The stainless-steel leading-edge main-rotor blades are of all-metal bonded construction, incorporating corrosion and scuff-resistant stainless-steel leading edges 0.020 inch thick.

c. The cobalt-steel leading-edge main-rotor blades are also of all-metal bonded construction, but incorporate cobalt-steel leading edges. The thickness of the leading edge is 0.040 inch, twice that of the stainless-steel leading edge. A capability is incorporated into the blades for adding weights to the tip end to facilitate balancing.

d. The weight is the same for both the cobalt- and stainless-steel blades, and the blades are interchangeable when new.

4. Background. The UH-1( ) product-improvement program is a continuing attempt to correct these problem areas discovered during testing and field use, to improve the operational capabilities of the UH-1( ), and to reduce the support requirements of the helicopter. One part of the product-improvement program is to develop a means to protect helicopter rotor blades against excessive deterioration from the effects of sand, rain, and dust. Although time between overhaul (TBO) is 1100 hours, experience has shown that UH-1D Helicopters operating in dusty and/or sandy environments frequently require rotor-blade replacement after 300 hours of operation or less. Some stainless-steel blades operated at Fort Benning, Georgia, were condemned because erosion occurred at as little as 165 hours' flying time. The following evaluations were made in an attempt to improve the erosion resistance of the blades.

a. Informal Evaluation. In 1961, the US Army Aviation Test Board (USAAVNTBD) informally evaluated helicopter blade-erosion preventive materials and found them to be inadequate.

b. YUH-1D Service Test. In 1962 during the desert portion of the service test of the YUH-1D Helicopter (reference 1b), the USAAVNTBD tested two Neoprene rotor-blade erosion-preventive kits with boot thicknesses of 0.065 inch and 0.095 inch. These kits demonstrated considerable potential.

c. US Army Transportation and Research Command (USATRECOM) Technical Report. USATRECOM (now the US Army Aviation Materiel Laboratories (USAAML)) initiated a research and development contract with the prime objective of finding a suitable material which would protect the main-rotor blades of helicopters in a desert environment and which would withstand other extreme environmental conditions, such as rain, snow, and dust. Phase I results were published in TCREC Technical Report 62-111 (reference 1a). As a result of testing, Polyurethane was selected as the most promising erosion-resistant material for protecting helicopter blades in a desert environment.

d. Military Potential Test. As a result of the service-test findings, the Iroquois Project Manager contracted with the manufacturer for two types of erosion-preventive kits (Estane and Neoprene) for military potential testing. A third type of kit (Polyurethane) was included as the result of research and testing conducted by USATRECOM. The USAAVNTBD conducted a comparative military potential test of the three kits from March 1964 to February 1965 (reference 1h). It was concluded that, because of the effects of rain on the boots, none of the kits possessed military potential for use in tropic and temperate areas, but that they possessed military potential for use in arid areas.

e. USAAML Report. USAAML completed and published a report (reference 1f) of their findings on use of Polyurethane as an erosion-resistant material. USAAML concluded that Polyurethane is a suitable erosion-resistant material for helicopter rotor blades in the desert, and that continuing research is required to obtain a better protective system for all environments.

f. Cobalt-Steel Leading-Edge Blades. Two prototype 48-foot cobalt-steel blades (0.020 inch thick) were installed and tested on a YUH-1D Helicopter during July and August 1965 in conjunction with the T53-L-11 Engine Inlet-Air Barrier Filter and Particle Separator Product Improvement Test (reference 1n). Test results were inconclusive. Cobalt-steel blades (0.040 inch thick) were subsequently put into production and are being used to replace stainless-steel blades. The Iroquois Project Manager requested that the production 48-foot cobalt-steel blades be tested during the second phase of the Engine Inlet-Air Barrier Filter and Particle Separator Product Improvement Test, and a test directive (paragraph 2a(1)) was issued to the USAAVNTBD by USATECOM.

5. Scope.

a. The USAAVNTBD began the product-improvement test with one cobalt-steel blade paired with one stainless-steel blade on a main-rotor hub for each of two YUH-1D Helicopters. The leading edge of

each rotor blade was photographed prior to the initiation of testing. The helicopters were hovered in an extremely sandy and dusty environment to accelerate blade erosion. The leading edge of each blade was visually inspected at the conclusion of each flight period and photographs were made of significant changes.

b. Blade A2-2587 (cobalt steel) was paired with blade A2-1837 (stainless steel) on one helicopter, and blade A2-2772 (cobalt steel) was paired with blade A2-1621 (stainless steel) on the second helicopter. The stainless-steel blades on both helicopters failed after operation in the sandy environment and new stainless-steel blades were installed. However, because of erosion, the cobalt-steel blades would not balance with the new blades. Both stainless-steel blades were installed subsequently on one helicopter and both cobalt-steel blades were installed on the other. The helicopters were then hovered in the same sandy area until all blades became unserviceable.

c. All blades tested were sent to the manufacturer for analytical inspection. The operating time, appearance, and condition of the cobalt-steel blades and the stainless-steel blades were compared.

6. Summary of Results.

a. Operating time in sandy and dusty environments for each blade prior to failure was:

Cobalt-Steel Blades	Sand and Dust Time (hours)
A2-2587	5.7
A2-2772	5.7

Stainless-Steel Blades	Sand and Dust Time (hours)
A2-1837	2.7
A2-1621	2.7
A2-1483	3.0
A2-418	3.0

b. Significant conditions of the leading edges were:

Blade No.	Sand Time (hours)	Condition
A2-1837	2.7	Failure of stainless steel (figure 1, inclosure 1).
A2-2587	2.7	Slight deterioration of cobalt-steel blade paired with stainless-steel blade A2-1837 (figure 2, inclosure 1).
A2-1621	2.7	Failure of stainless steel (figure 3, inclosure 1).
A2-2772	2.7	Slight deterioration of cobalt-steel blade paired with stainless-steel blade A2-1621 (figure 4, inclosure 1).
A2-1483	3.0	Failure of stainless steel (figure 5, inclosure 1).

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Blade No.	Sand Time (hours)	Condition
A2-418	3.0	Failure of stainless steel (figure 6, inclosure 1).
A2-2587	4.7	Slight wrinkling of cobalt steel (figure 7, inclosure 1).
A2-2772	4.7	Slight wrinkling of cobalt steel (figure 8, inclosure 1).
A2-2587	5.7	Failure of cobalt steel (figure 9, inclosure 1).
A2-2772	5.7	Failure of cobalt steel (figure 10, inclosure 1).

c. The manufacturer's analytical report stated that the cobalt-steel leading edges had an apparent wear-rate improvement of 23 percent over that of the stainless-steel leading edges, and can be expected to have a life 2.9 times that of the stainless-steel leading edges. These figures are not substantiated by results of this test.

7. Conclusions.

a. UH-1D main-rotor blades with cobalt-steel leading edges (0.040 inch thick) remain serviceable approximately twice as long as blades with stainless-steel leading edges (0.020 inch thick).

b. The increased service life of cobalt-steel blades, as tested, cannot be solely attributed to any improved erosion-resistant characteristics of cobalt-steel over stainless-steel edges.

c. Thickness of selected leading-edge material is a significant factor in rotor-blade life in a sandy environment.

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8. Recommendations. It is recommended that:

a. Cobalt-steel blades (0.040 inch thick) be considered as interim replacements for stainless-steel blades on UH-1D Helicopters exposed to highly erosive sand and dust environments.

b. Previous Army research and testing (references 1a and 1f) be thoroughly investigated to determine whether other materials may be more suitable than cobalt steel for universal Army application with additional developmental effort.

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Photographs

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PHOTOGRAPHS

INCLOSURE 1

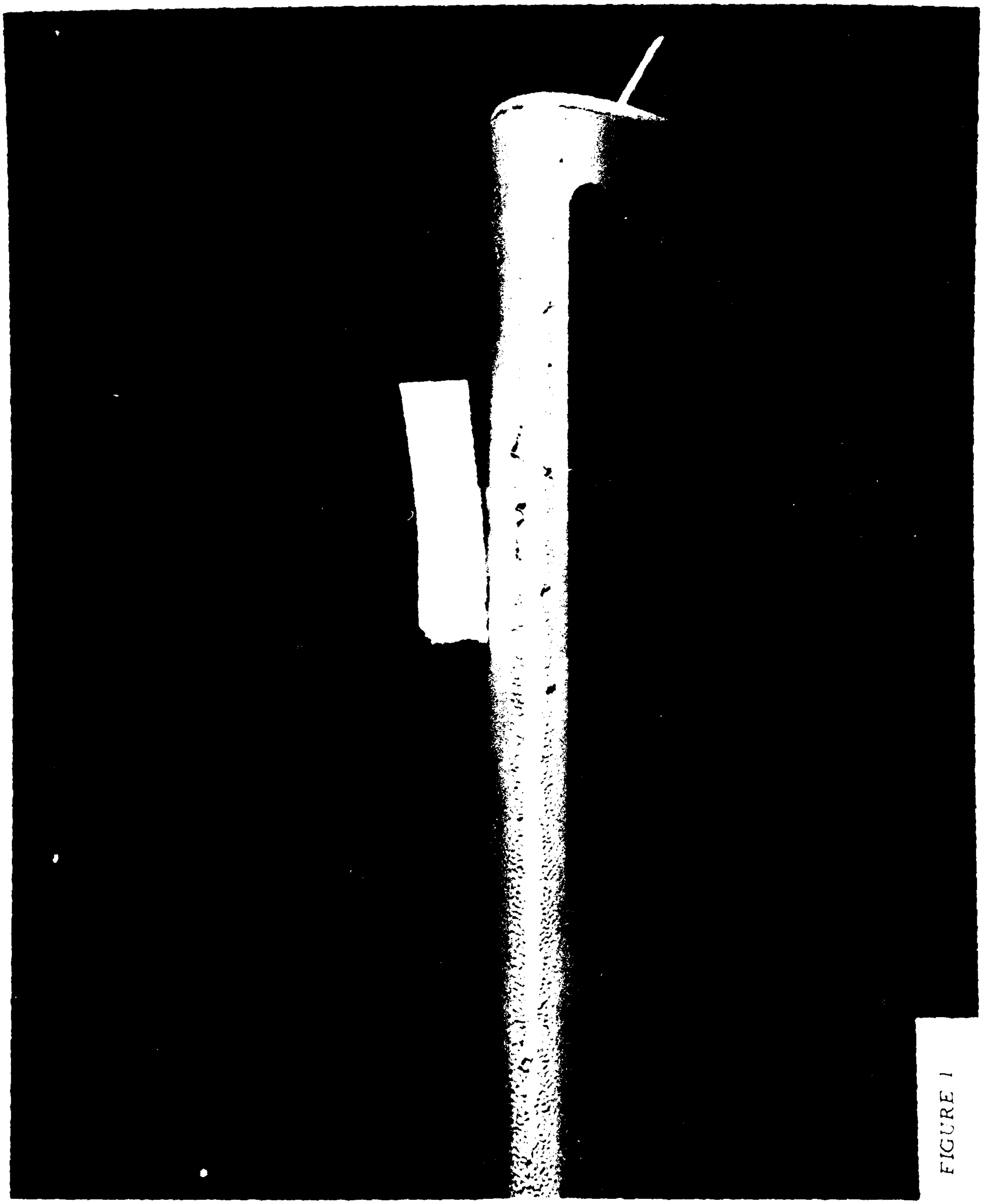


FIGURE 1

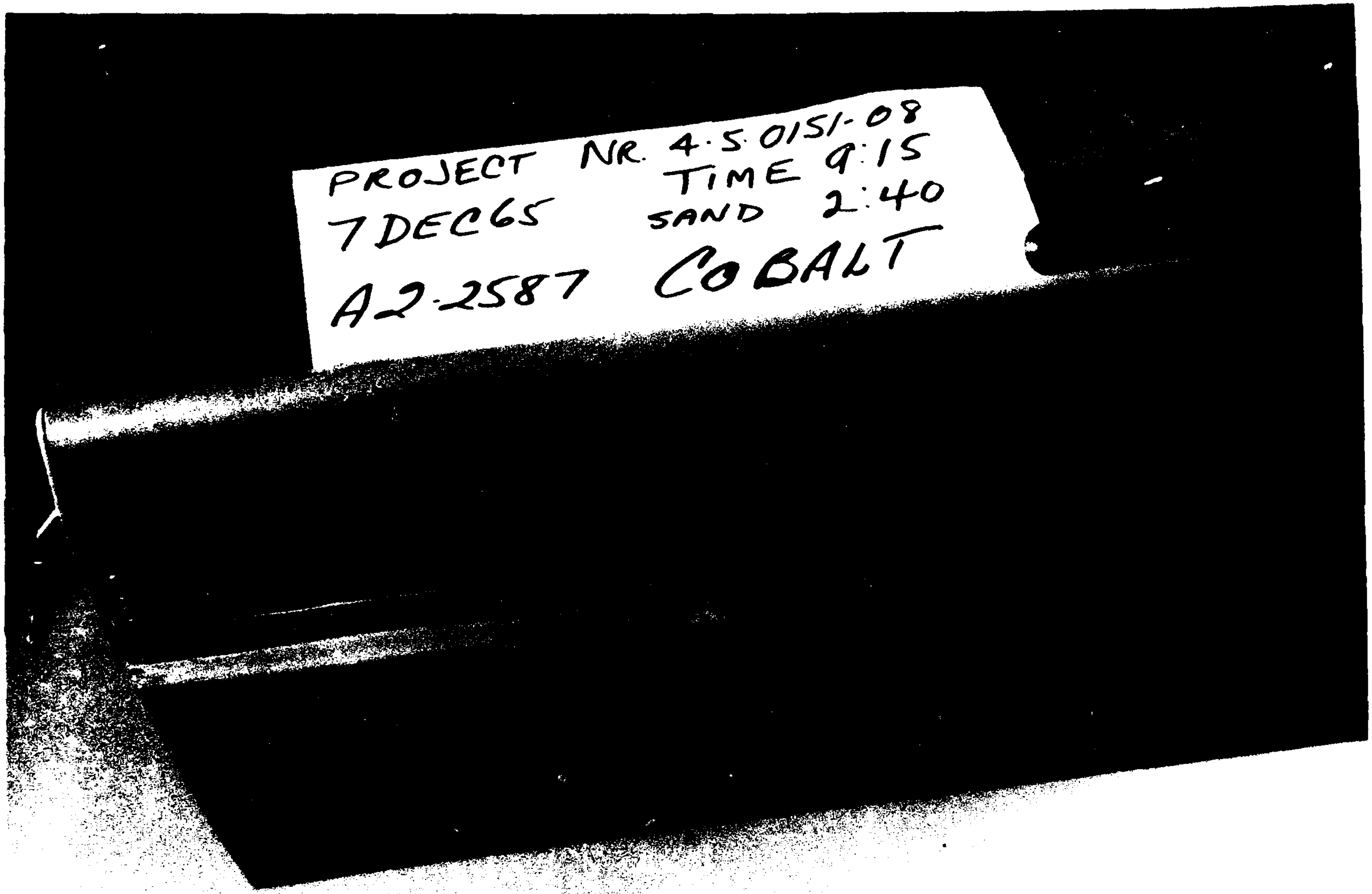
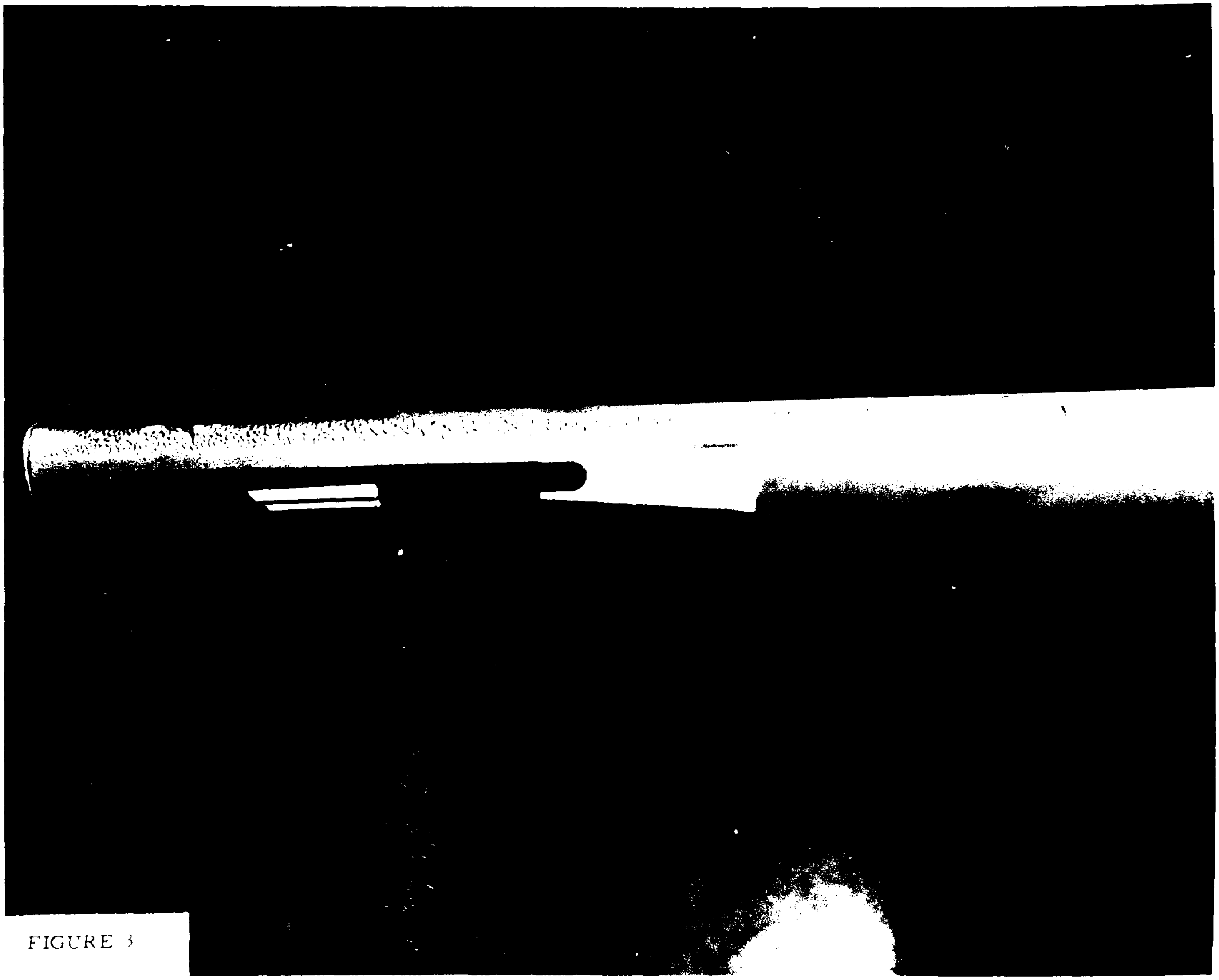


FIGURE 2



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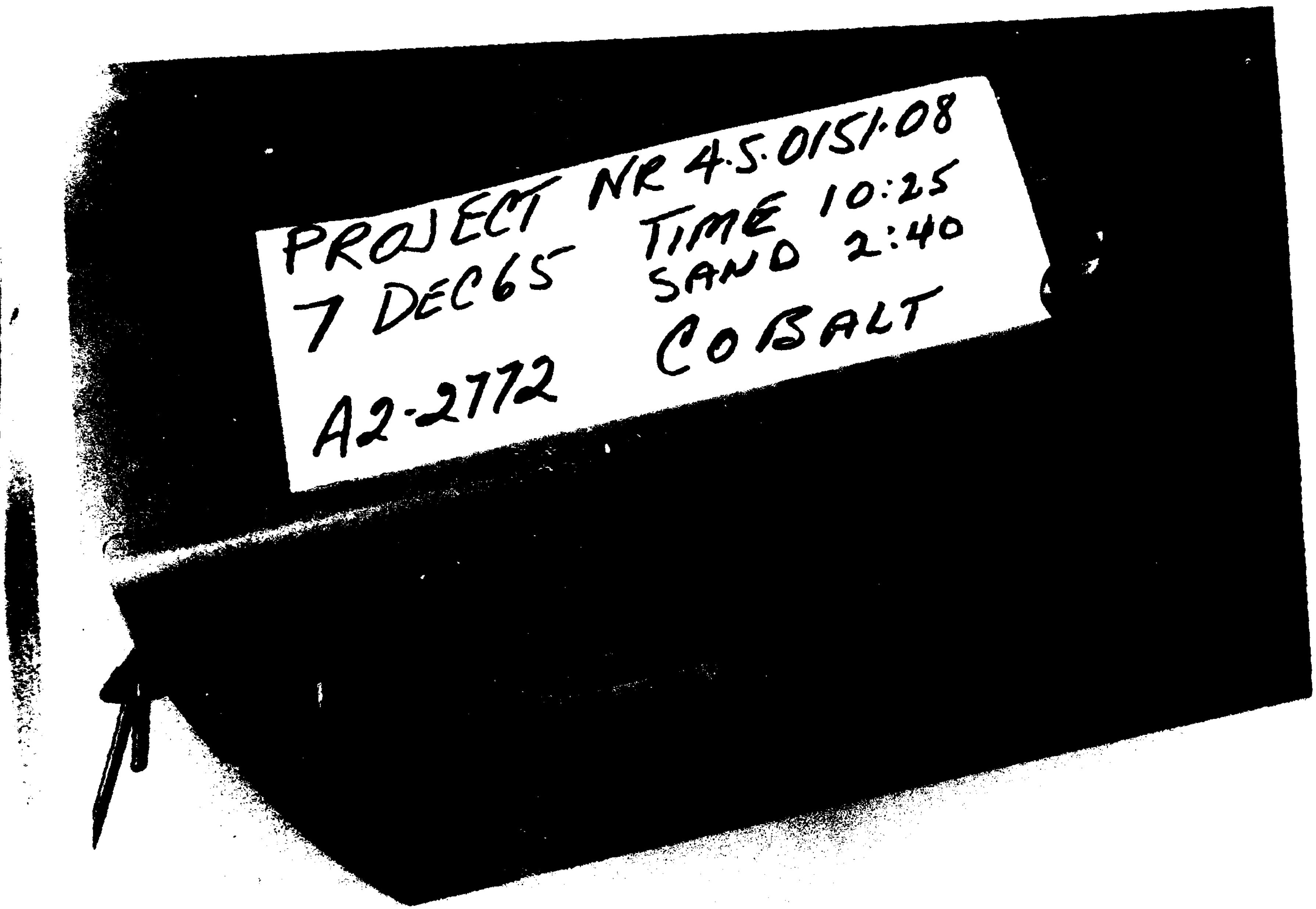
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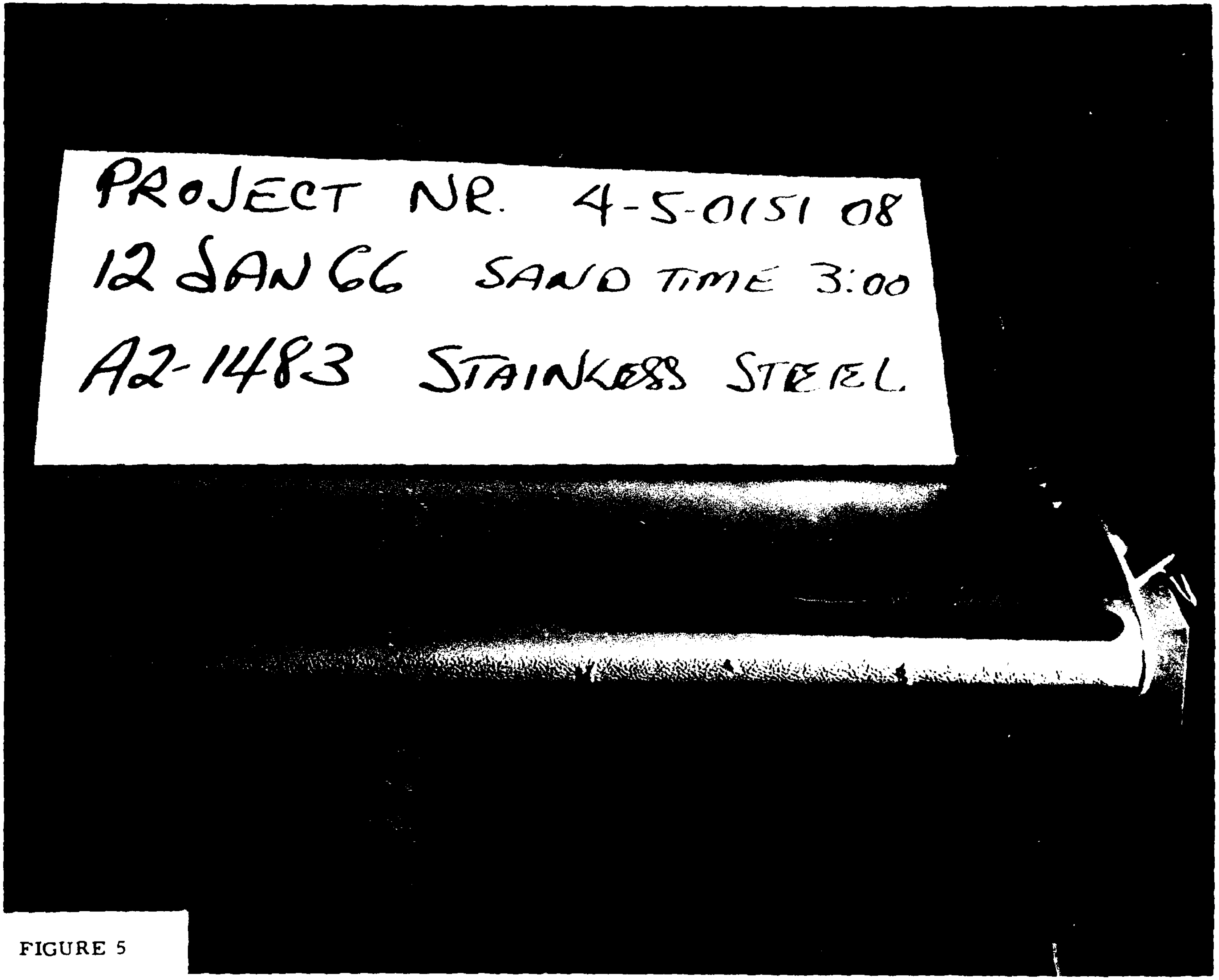
A2-2772 COBALT

FIGURE 4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A2-1483 STAINLESS STEEL

FIGURE 5

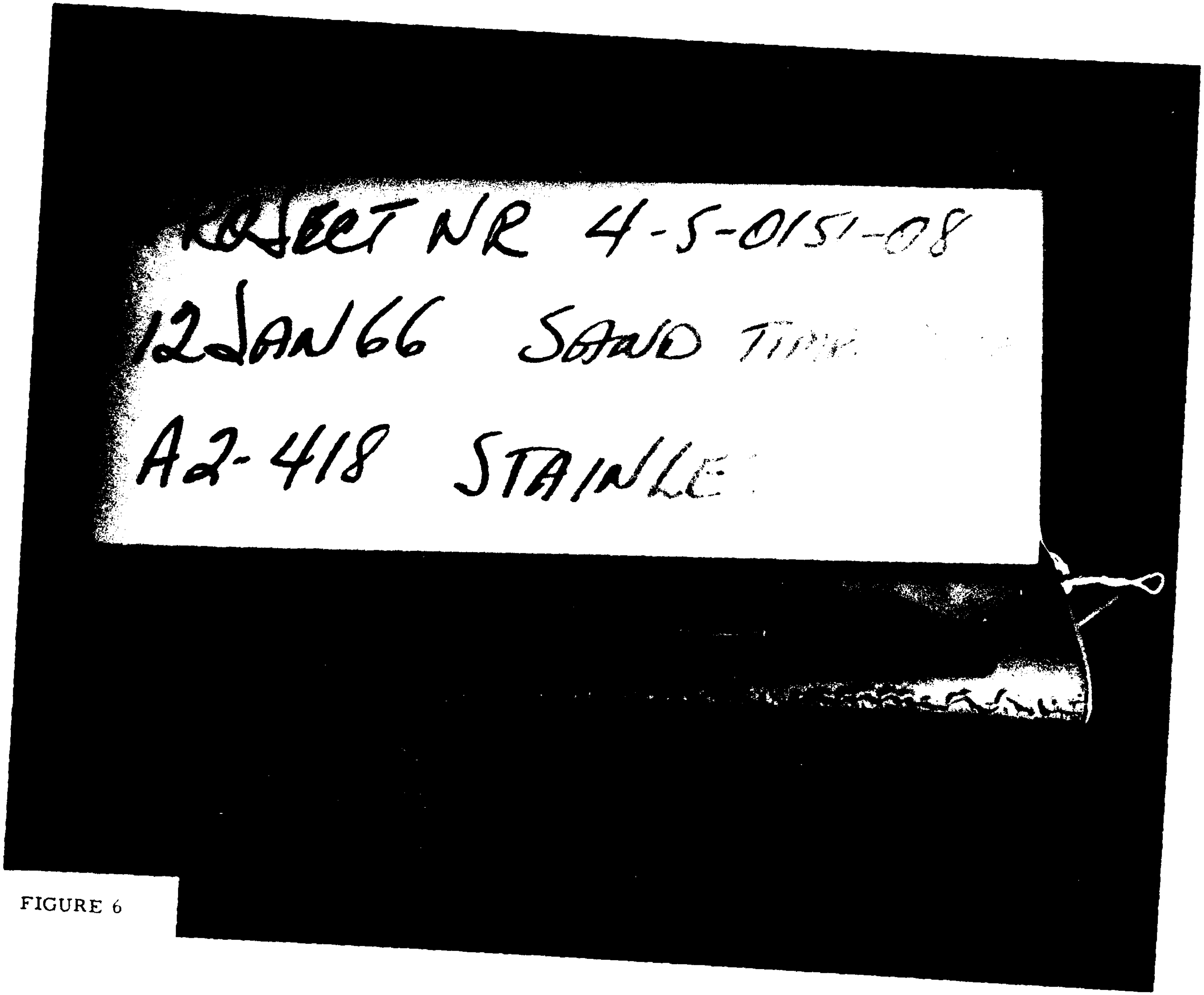

FIGURE 6

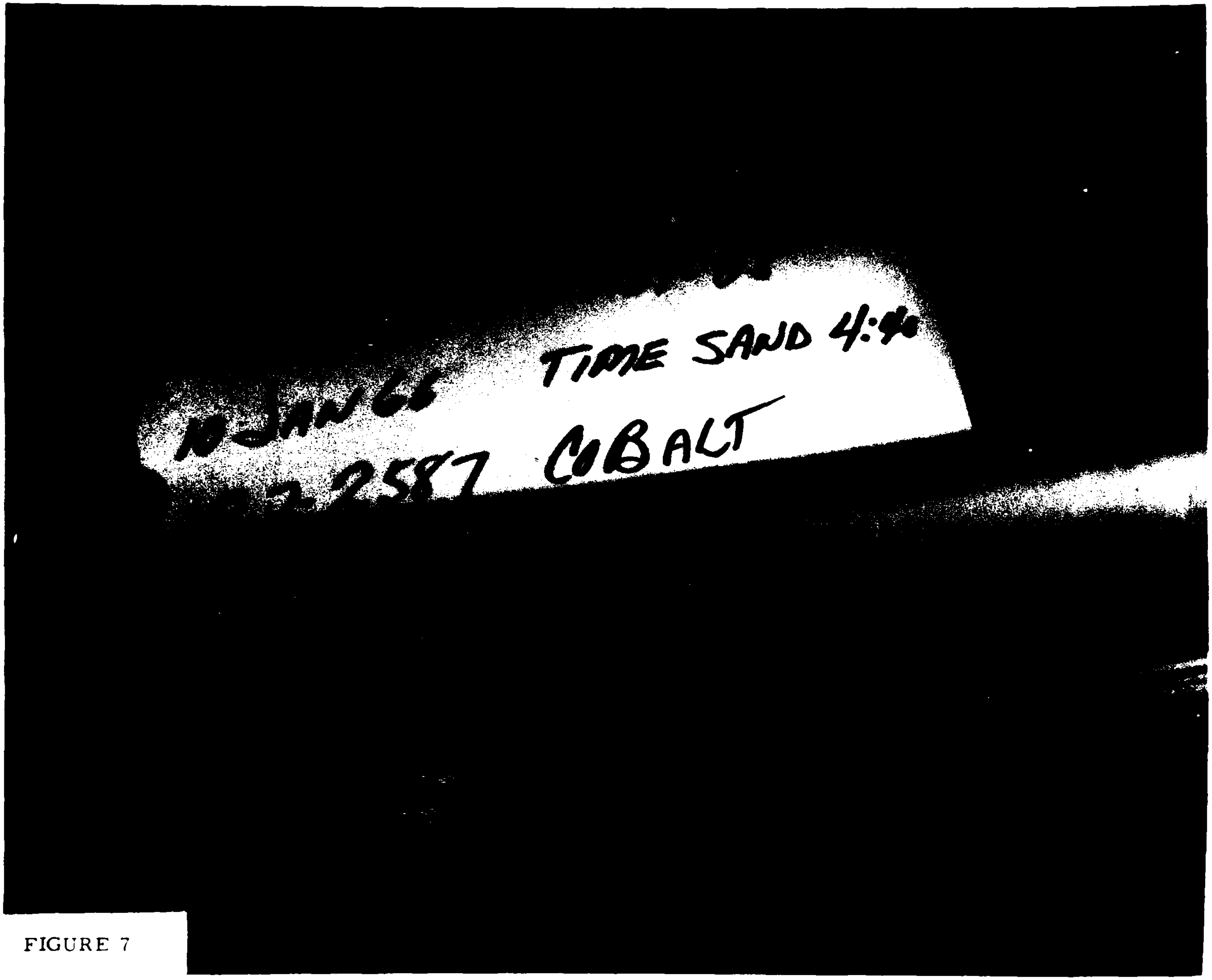

FIGURE 7

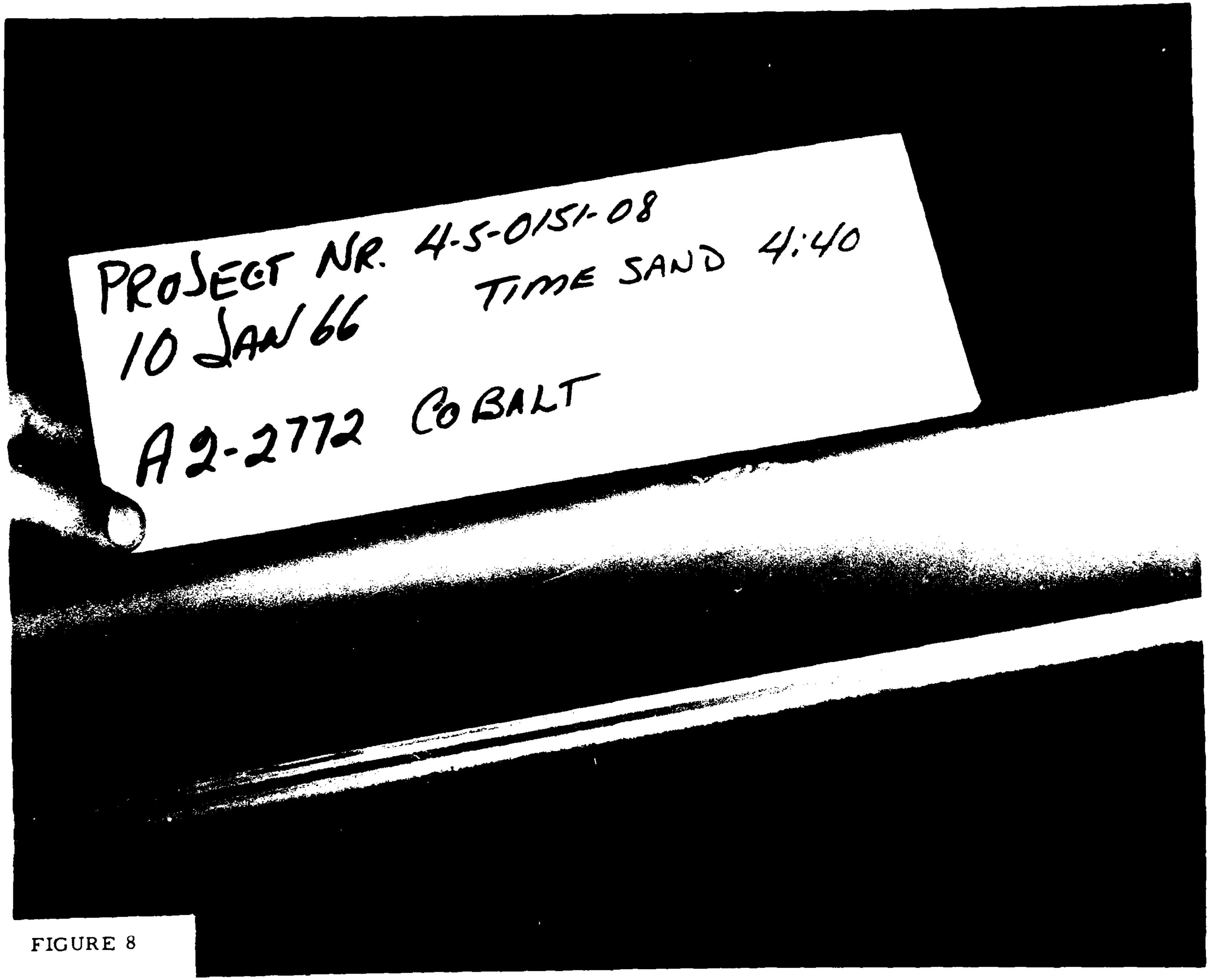

FIGURE 8

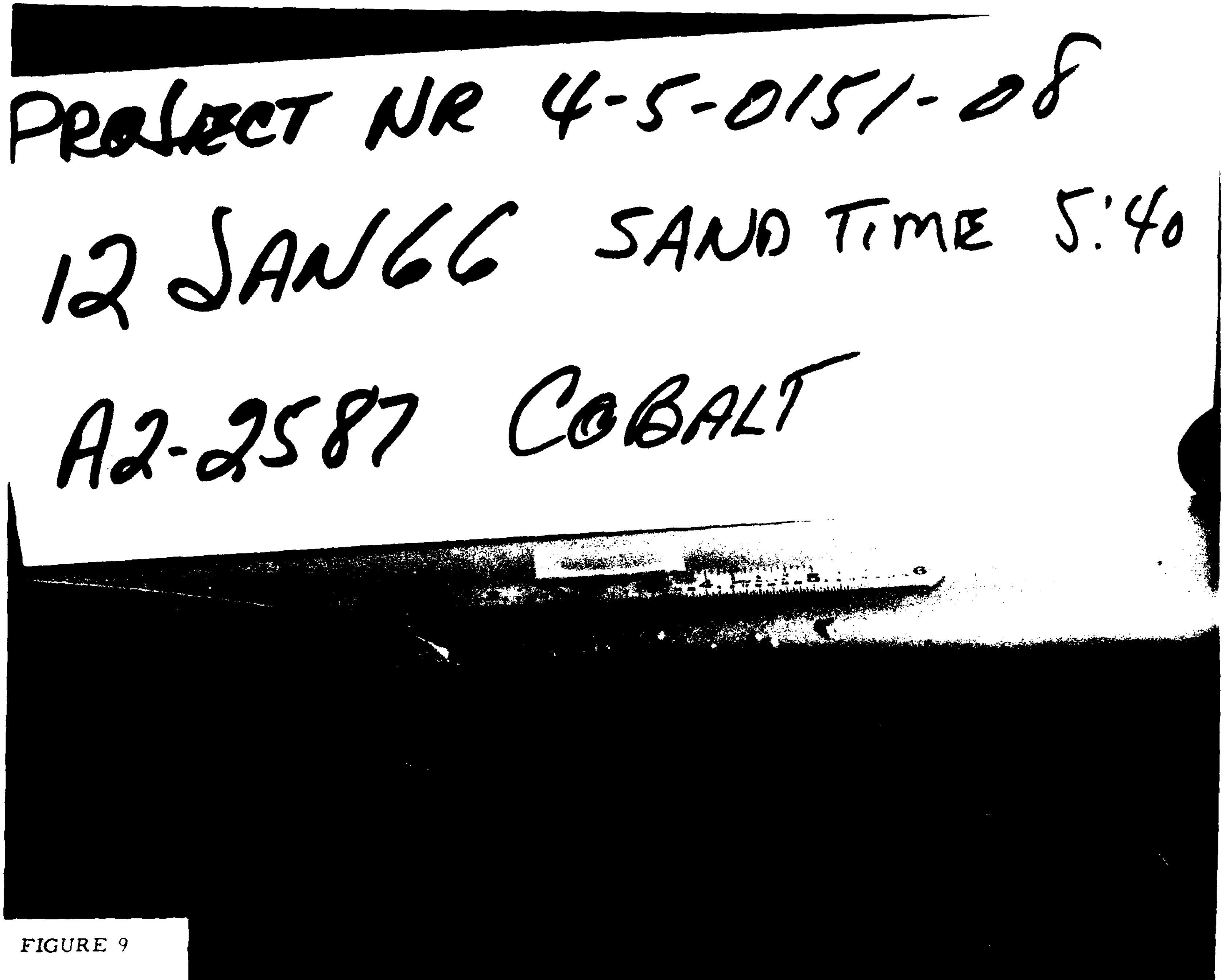

FIGURE 9

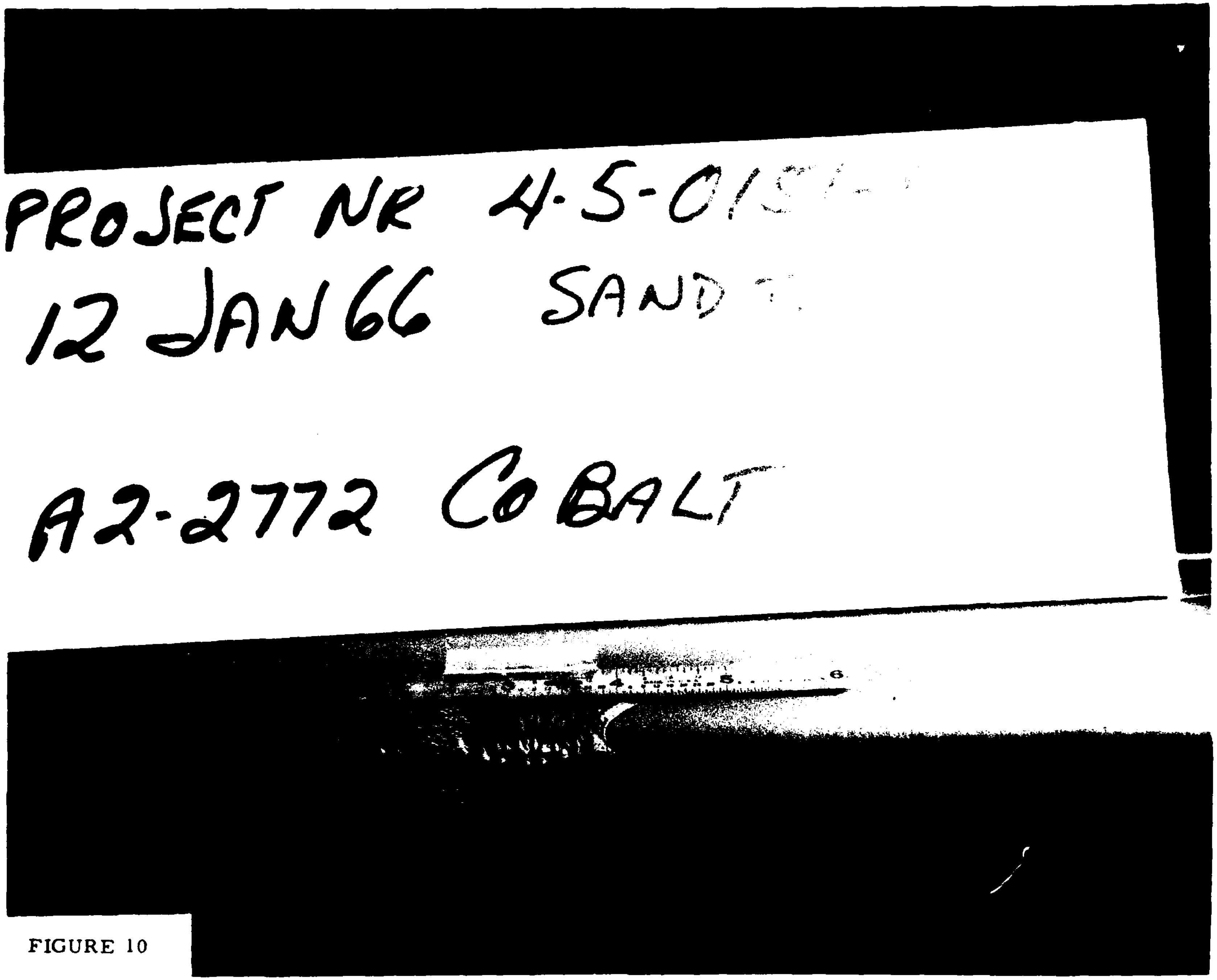

FIGURE 10